

A NEW TROGLOBITIC CRAYFISH,
PROCAMBARUS (LONNBERGIUS) MORRISI,
(DECAPODA: CAMBARIDAE) FROM FLORIDA

Horton H. Hobbs, Jr. and Richard Franz

Abstract.—*Procambarus (Lonnbergius) morrиси*, an albinistic troglobite, is described from Devil's Sink, seven kilometers west of Interlachen, Putnam County, Florida. Having its closest affinities with *P. (L.) acherontis* (Lönnerberg), it is the second crayfish to be assigned to the subgenus. It may be distinguished from the latter species by possessing a well developed cephalic process on the first pleopods of first form males and by the looped sculpturing on the annulus ventralis in the females. This is the only albinistic crayfish in which the first pleopod of the male lacks a mesial process. Emended diagnoses of the subgenus and *P. (L.) acherontis* are presented.

The discovery of *Procambarus (Lonnbergius) morrиси* in Devil's Sink, Putnam County, Florida, extends the northeastern limit of the geographic range of the troglobitic crayfishes of Florida to the southern flank of Trail Ridge. There the latter forms the drainage divide between the St. Johns River, which flows into the Atlantic Ocean, and the Santa Fe River, a major tributary of the Suwannee River that flows into the Gulf of Mexico. Surprisingly the closest relative of this crayfish is not one of the troglobites, the ranges of which are most proximate (less than 40 km to the southwest and west) and encompass parts of the Santa Fe Basin. Rather, it is another albinistic form, *P. (L.) acherontis* (Lönnerberg, 1894), which inhabits subterranean waters in the area of headwaters of the St. Johns River, some 120 km to the south.

These crayfishes are obviously closely allied, and the differences noted between them are largely limited to those occurring in the secondary sexual features. Inasmuch as the diagnosis of the previously monotypic subgenus *Lonnbergius* (Hobbs, 1972) was identical to that of *P. (L.) acherontis*, there is need to modify it to include the new species. Moreover, specimens of *P. (L.) acherontis*

from additional localities necessitate at least a slight modification of the diagnosis of that species. These diagnoses precede the diagnosis and description of *P. (L.) morrиси*.

Subgenus *Lonnbergius*

Diagnosis.—(Modified from Hobbs 1972: 8.) Albinistic; eyes reduced and without pigment. Rostrum with pair or several marginal spines or tubercles but lacking dorsomedian longitudinal carina. Carapace without cervical spines. Areola 7.3 to 23.8 times as long as broad and constituting 38.1 to 45.6% of entire length of carapace (45.7 to 54.7% of postorbital carapace length). First three pairs of pereopods without conspicuous brush of setae extending from basis to merus. Hooks on ischia of third and fourth pereopods simple or bituberculate. Coxa of fourth pereopod with prominent vertically disposed caudomesial boss. First pleopod reaching coxa of third pereopod, symmetrical, with proximomedian lobe but lacking proximomesial spur; no shoulder on cephalic surface; subapical setae present or absent. Terminal elements of first pleopod in first form male consisting of mesial process which present or absent; cephalic pro-

cess well developed, rudimentary, or absent; prominent caudal process, flanked by protuberances on ridge of caudal knob; and very conspicuous, subacute, distally directed central projection. (Mesial lamella much shorter than in other members of genus, exposing much of median lamella proximal to bases of caudal element and centrocaudal process.) Mesial ramus of uropod with median spine acute but never reaching distal margin of ramus. Female with caudally projecting tuberculate, often spiniform, prominences lateral to median cleft on tuberculate sternite immediately cephalic to annulus ventralis.

Remarks.—The discovery of the new crayfish described herein necessitates a modification of couplet 14 in Hobbs' (1972: 4) key to the subgenera of the genus *Procambarus* as follows:

- 14(13') Bituberculate hooks on ischia of third and fourth pereopods (fig. 1*i*) or mesial process of first pleopod absent *Lonnbergius*
 14' Bituberculate hooks never present on ischia of both third and fourth pereopods (fig. 1*i*); mesial process of first pleopod always present 15

Procambarus (Lonnbergius) acherontis
 (Lönnerberg, 1894)

Cambarus acherontis Lönnerberg, 1894:125.
Procambarus acherontis.—Hobbs, 1942: 342.

Diagnosis.—Areola 14 to 23.8 times as long as broad, comprising 41 to 44% of entire length of carapace, 49.8 to 52.6% of postorbital carapace length. Ischium of third and fourth pereopods with bituberculate hooks. First pleopod of first form male with or without subterminal setae, if present, limited to longitudinal row of 3 to 5 sparsely plumose setae on cephalic margin; slender mesial process of variable length, ranging from falling short of to almost reaching dis-

tal margin of shaft of appendage; cephalic process rudimentary or absent; caudal element consisting of small, corneous, cephalodistally directed caudal process flanked by bulges on distal rim of caudal knob; and corneous, compressed, subtriangular, distally directed central projection situated anterior to and slightly overreaching caudal process; rudimentary process lacking from distal rim of lateral lamella between cephalic and caudal processes. Female with annulus ventralis bearing cephalolateral tubercles and caudomedian sinuous sinus.

Procambarus (Lonnbergius)

morrissi, new species

Fig. 1

Cavernicolous crayfish from Putnam County [Florida].—Franz & Franz 1991.

Diagnosis.—Areola 7.3 to 12.7 times as long as broad, constituting 38.6 to 45.6% of entire length of carapace, 47.1 to 51.8% of postorbital carapace length. Ischium of third and fourth pereopods never with clearly defined bituberculate hooks. First pleopod of first form male with row of 2 or 3 subterminal plumose setae at caudomesial base of cephalic process; mesial process absent; cephalodistally directed cephalic process well developed, acute, subtriangular, and almost reaching or slightly overreaching apices of other terminal elements; caudal element consisting of small, corneous cephalodistally directed caudal process arising from rim of caudal knob; compressed, corneous central projection extending distally between caudal and cephalic processes; and short, rounded, rudimentary process borne on distal rim of lateral lamella between cephalic and caudal processes. Female with subtriangular annulus ventralis, lacking cephalolateral tubercles but bearing caudoventral complexly looped sinus.

Holotypic male, form I.—Body subovate, distinctly depressed (Fig. 1*a*, 1). Abdomen narrower than thorax (8.5 and 11.1 mm). Greatest width of carapace at about 0.2

length of areola from cephalic margin where width greater than height (11.1 and 8.1 mm); width noticeably constricted at level of caudodorsal margin of cervical groove. Areola 8.1 times as long as broad, comprising 38.6% of entire length of carapace (47.1% of post-orbital carapace length) and, although with room for more, bearing single sublinear series of punctations in narrowest part. Cephalic section of carapace 1.6 times as long as areola. Surface of carapace punctate over rostrum, dorsal gastric region, areola, and orbital and antennal regions; otherwise mostly tuberculate. Rostrum comparatively broad basally, tapering to marginal spines at base of short acumen, latter reaching midlength of ultimate podomere of antennular peduncle; rostral margins slightly thickened and finely subserrate posteriorly and anteriorly, less distinctly so between margins; dorsal surface concave, lacking median carina. Subrostral ridges weak and evident in dorsal aspect only along basal fifth of rostrum. Postorbital ridges well defined, marked by linear series of tubercles posteriorly and terminating in short, acute, corneous tips. Suborbital angle represented by low rounded bulge. Branchiostegal spine virtually wanting; caudal flank of cervical groove with row of small tubercles, of which one probably homologous to cervical spine but not recognizable as such.

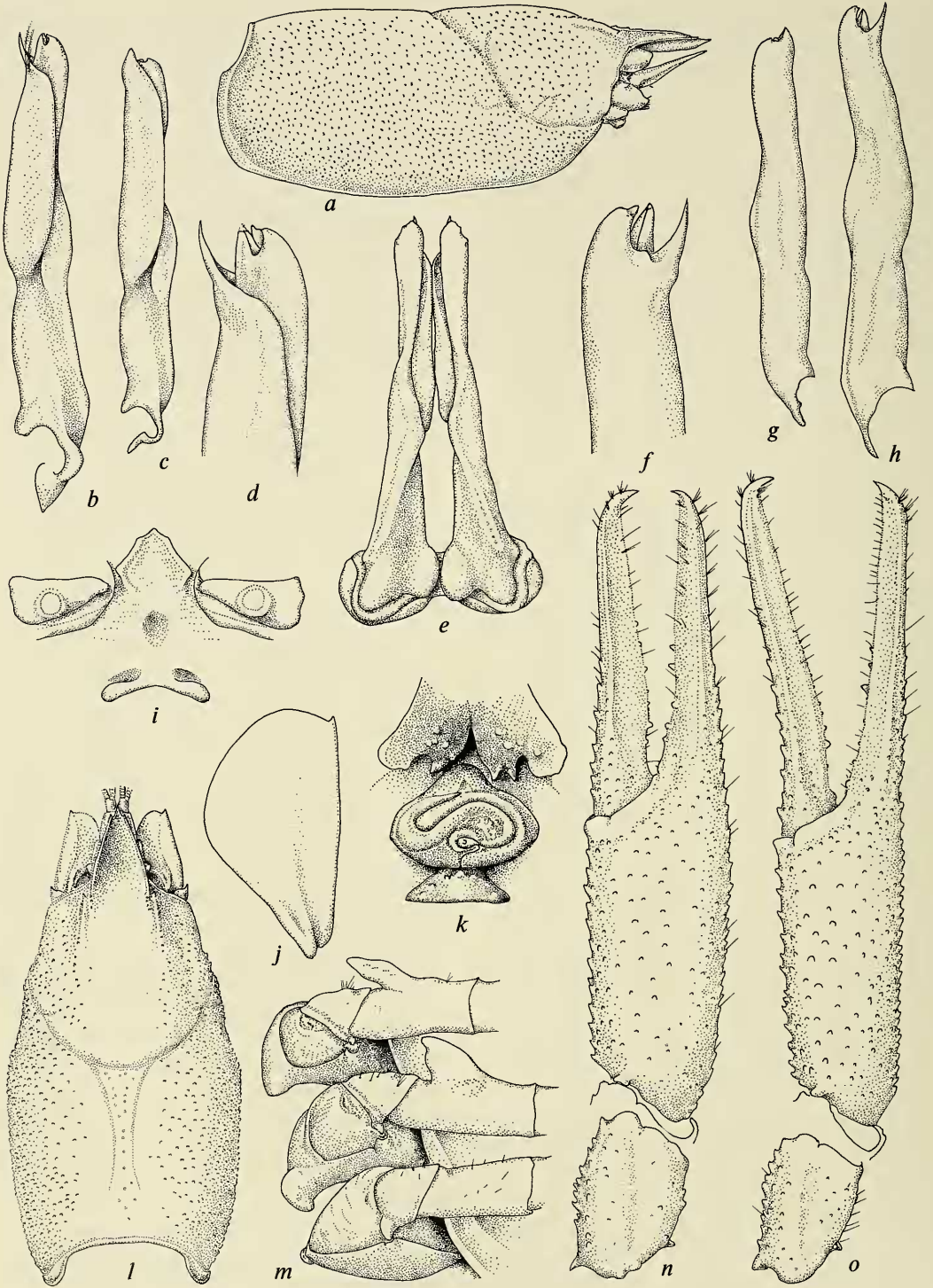
Abdomen subequal in length to carapace. Pleura of third through sixth segments truncate ventrally; those and that of second segment with caudoventral extremity angulate. Cephalic section of telson with 1 (right) or 2 (left) fixed spines in caudolateral corners. Cephalic lobe of epistome (Fig. 1i) subpentagonal in outline, with elevated (ventrally) margins; main body with prominent antero-medial depression containing anteriorly situated fovea. Ventral surface of proximal podomere of antennular peduncle with prominent spine at about midlength. Antennular peduncle with moderate spine on both basis and ischium; flagellum (about 60 mm in length) overreaching abdomen by about

10 mm. Antennal scale (Fig. 1j) 1.8 times as long as wide, broadest slightly distal to midlength; greatest width of lamellar area almost twice that of thickened lateral part.

Third maxilliped reaching base of ultimate podomere of antennular peduncle; ischium not produced distolaterally, bearing short, simple setae, but longer ones on post-axial flank of crista dentata and at mesial base.

Right chela (Fig. 1o) subovate in cross section, weakly depressed; length of mesial margin of palm about 2.2 times width, little more than 0.33 total length of chela; entire palm studded with tubercles, although irregularly arranged along mesial margin of palm, 12 to 14 appearing in silhouette. Both fingers with well defined dorsal and ventral longitudinal ridges flanked by tubercles proximally and setiferous punctations more distally. Opposable margin of fixed finger with row of 5 dorsally situated tubercles in proximal third, followed by row of 3 (proximalmost largest on margin) more ventrally situated ones in adjacent seventh; very narrow band of minute denticles beginning almost at base of finger, and broadening at level of largest tubercle, continuing distally to base of distal tenth of finger before tapering to base of corneous tip; lateral surface of finger with tubercles along proximal half and row of setiferous punctations distally. Opposable margin of dactyl with row of about 10 tubercles (second from base largest, and more distal ones no larger than, and difficult to distinguish from, adjacent minute denticles) extending from base slightly beyond midlength of finger; minute denticles distributed as on fixed finger; mesial surface with tubercles scattered basally, but cluster narrowing distally with single distalmost tubercle situated just proximal to midlength of finger.

Carpus of cheliped longer than broad with shallow median longitudinal depression flanked mesially by sublinear series of tubercles and laterally by few smaller tubercles and punctations; mesial surface tuber-



culate, but no tubercle conspicuously more prominent than others; ventral and lateral surfaces more sparsely tuberculate, ventrodistal margin with large tuberculiform condyle and more mesial single tubercle larger than others proximal and lateral to it.

Merus entirely tuberculate although weakly so proximomesially and proximo-laterally; almost all of dorsal margin serrate with no tubercles conspicuously larger than others nearby; ventral surface with irregular mesial row of 17 or 18 tubercles extending almost from base to distal end of podomere and poorly defined lateral row of 16 or 17; other tubercles present to the sides of both rows. Tuberculate ischium with mesial row of 7 tubercles; suflamen well developed.

Hooks on ischia of third and fourth pereopods (Fig. 1m), that on third more slender, reaching much proximal to basioischial articulation, and opposed by conspicuous tuft of setae, but no tubercle, on basis; hook on fourth pereopod robust with undulating proximal margin suggesting bituberculate condition of hooks in *P. (L.) acherontis*. Coxa of fourth pereopod with strong vertically disposed caudomesial boss; that of fifth pereopod with tuberculiform boss.

Sternum between third, fourth, and fifth pereopods moderately deep; ventrolateral margins with such delicate plumose setae that although covered ventrally, pleopods in usual position clearly visible.

First pleopods (Fig. 1b, d, e, f, h) as described in "Diagnosis."

Uropods with lobes of basal podomere bearing acute spines; both rami broad and with distolateral spine; distomedian spine

Table 1.—Measurements (mm) of *Procambarus (Lonnerbergius) morrissi*, new species.

	Holo-type	Allotype	Mor-pho-type
Carapace			
Entire length	21.0	18.8	17.9
Postorbital length	17.2	15.8	14.2
Width	11.1	10.8	9.4
Height	8.1	7.9	7.2
Areola			
Width	1.0	0.7	0.8
Length	8.1	7.5	7.0
Rostrum			
Width	3.0	2.8	2.2
Length	4.0	3.5	3.3
Right chela			
Length, palm mesial margin	6.7	5.0	5.4
Palm width	3.0	2.9	2.5
Length, lateral margin	17.2	12.6	15.0
Dactyl length	9.5	6.2	7.0
Abdomen			
Width	8.5	7.9	6.8
Length	21.0	18.3	17.8

of mesial ramus situated much proximal to broadly rounded distal margin.

Allotypic female.—Differing from holotype, other than in secondary sexual features in following respects (See Table 1 for differences in proportions of carapace and chela.): areola 10.7 times as long as wide; rostrum reaching base of ultimate podomere of antennular peduncle; branchiostegal spine very small and acute; telson with 2 fixed spines in each caudolateral corner; third maxillipeds not quite reaching distal end of proximal podomere of antennular peduncle, distolateral angle produced in short,

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 Fig. 1. *Procambarus (Lonnerbergius) morrissi*, new species (holotype except c, g from morphotype, and k, n from allotype): a, lateral view of carapace; b, c, mesial view of first pleopod; d, distal part of first pleopod in mesial view; e, caudal view of first pleopods; f, distal part of first pleopod in lateral view; g, h, lateral view of first pleopod; i, epistome and part of basal podomeres of antennae; j, antennal scale; k, annulus ventralis and adjacent sternites; l, dorsal view of carapace; m, basal podomeres of third, fourth, and fifth pereopods; n, o, dorsal view of distal podomeres of cheliped.

acute spine. Opposable margin of fixed finger of chela (Fig. 1n) with dorsally situated row of 3 tubercles and more ventral one of 2, opposable margin of dactyl with row of 7 tubercles, minute denticles on both fingers arranged in single row; merus with ventrolateral row of 21 tubercles and ventromesial one of 18; ischium with row of 6 tubercles mesially.

Annulus ventralis (Fig. 1k) subtriangular in ventral aspect with complexly contoured, oval, ventral face. Sinus originating on cephalomedian margin of latter and, after extending caudodextrally to near dextral margin, making hairpin turn and coursing in broad arc to near sinistral margin, there looping dextrally and slightly cephalically to median line where turning caudally and describing almost complete circular course before turning caudodextrally to median line and finally caudally to caudal margin of annulus.

Sternum immediately cephalic to annulus broadly V-shaped, deeply cleft, tuberculate, with two pairs of conspicuous, acute, caudally projecting prominences flanking and partly overhanging (ventrally) cephalic part of annulus. Postannular sclerite also subtriangular, three-fourths as wide as annulus, and bearing arc of tubercles. First pleopods uniramous but well developed.

Morphotypic male, form II.—Differing from holotype in following respects (See Table 1 for differences in proportions of carapace and chela.): tiny speck of brown pigment in right eye; apex of rostrum reaching base of ultimate podomere of antennular peduncle; branchiostegal spine well developed; cephalic section of telson with two pairs of spines in caudolateral corners; cephalic lobe of epistome subtrapezoidal with single prominent tubercle; antennal flagellum (about 57 mm in length) overreaching telson by approximately one-third of its length; third maxilliped reaching midlength of penultimate podomere of antennular peduncle, ischium produced distolaterally in small spine. Opposable margin of fixed fin-

ger of chela with dorsally situated row of 4 tubercles and more ventral one of 5; opposable margin of dactyl with row of 7 tubercles; minute denticles on both fingers mostly arranged in single row as in allotype; merus of cheliped with ventromesial row of 21 tubercles and ventrolateral one of 16; hooks on ischia of third and fourth pereopods reduced to knobs, neither overreaching basioischial articulation; boss on caudomesial angle of coxa of fourth pereopod prominent but less well defined.

First pleopod (Fig. 1c, g) with hoodlike, acute cephalic process largest of terminal elements, none of which corneous, and overreaching others; caudal process not differentiated from caudal knob; central projection tuberculiform, not reaching so far distally as caudal element; rudimentary process on distolateral margin of lateral lamella so reduced as to appear no more than slight bulge.

Type locality.—Devil's Sink, 152 m north of St. Rte. 20, 7.1 km west of Interlachen (junction of St. Rtes. 313 and 20), Putnam County, Florida (NE ¼, SE ¼, NW ¼, Sec. 13, Twp. 10S, R. 23E). Devil's Sink is located near the summit of a prominent sand ridge (elevation 45.7 m), approximately 220 m north of the northwest edge of Lake Galilee. The nearly circular rim of this steep-sided sink is approximately 30.5 m in diameter. The eastern and southern sides have been severely eroded by foot traffic, while the other slopes are forested with *Liquidambar styraciflua* and members of the genus *Quercus*. Five meters above the pool the diameter of the sink narrows to less than 18 m and continues to a vertical, water-filled shaft of similar dimension. The shaft reaches a maximum water depth of 31.7 m. A large detritus cone of sediment (surface debris and a Volkswagen car!) rises from the base of the sink to a water depth of 16.8 m. A small passage, approximately 30.5 m in length and leading southwest from the shaft, slopes to a small terminal room 3.7 by 6.1 m and 6.0 to 3.1 m in height. Maximum

water depth there is 37.5 m. Water in the cave is stratified, with the bottom layer having a rusty color and a slightly cooler temperature (22°C) than the clear upper layer. The limestone in contact with the rusty-water zone is stained, resembling a stained bath tub. The ceiling of the terminal room has dark areas with growths of possible iron bacteria and hanging strands of what may be sulfur bacteria. Crayfish were found only in the sloping passage and terminal room; none was observed in the shaft. They were found both in the rusty and clear water zones and appeared to move freely from one to the other. The exoskeletons of many of the individuals observed were stained with the color of the rusty water. Specimens of unidentified troglobitic amphipods were found with the crayfish in the cave. Centrarchid fishes were observed in the upper portions of the water column in the shaft, but not in the sloping passage and terminal room.

Geological notes.—Sediments that outcrop in the upper portions of the sink consist of coarse variegated sands associated with the Cypress Head Formation (=Citronelle Formation of Cooke 1945:236). Phosphatic clays of the Hawthorn Formation are exposed about 4.6 m above the sinkhole pool. The shaft is developed in this unit to a water depth of 31.7 m, at which level the Crystal River Formation is encountered. The small passage and terminal room are situated in the latter formation.

Disposition of types.—The holotype, allotype, and morphotype (♂ I, ♀, ♂ II) are deposited in the National Museum of Natural History (Smithsonian Institution) nos. 220374, 220375, and 220376, respectively, as are the paratypes, consisting of 2 ♂ I, 6 ♀, and 4 juvenile ♂.

Size.—The largest specimen available is the holotype which has a carapace length of 21.0 mm (postorbital carapace length 17.2 mm). The smallest first form male has corresponding lengths of 20.0 and 16.3 mm. Ovigerous females or ones carrying young have not been collected.

Range and specimens examined.—This crayfish is known only from the type locality. Two collections have been made by Tom Morris, one on 9 May 1989 consisting of 3 ♀ and 4 juv. ♂; the second one, with the assistance of Paul Smith, from minnow traps set at 33.5 m water depth on 6 March 1990 and retrieved two days later, consisting of 3 ♂ I, 1 ♂ II, and 4 ♀.

Devil's Sink is located in the extensive sand hill district associated with the Interlachen Karstic Highland (Pirkle & Pirkle 1984) on the southern flank of Trail Ridge. Dissolution of underlying carbonates of the Hawthorn Formation (Miocene) and the Ocala Limestones (Eocene) have secondarily modified the landscapes, particularly in the inter-dune areas, to form circular depressions. Many of these sinks are filled with water and form lakes and ponds in the region. Paleo-sinks that open in some of the lake basins are usually filled with sediments and do not openly connect with underlying carbonate rocks. Deevey (1988) has calculated leakage rates through these sinks for several of the lakes in this area. To our knowledge, Devil's Sink is the only such sinkhole in the entire area that has a direct connection with a carbonate aquifer in the entire southern Trail Ridge region. The surficial aquifer that controls lake levels in the area has a water quality different from that found in Devil's Sink.

Variations.—In addition to the variations pointed out in the primary types, the rostral margins may be clearly serrate or subtly so, and the number of tubercles at the base is usually fewer than in the holotype. The anterior lobe of the epistome is more frequently subrhomboidal than pentagonal and the tubercle noted in the allotype is unique among our specimens. The cephalic section of the telson may bear one to three spines in the caudolateral corner. Details of the hooks on the ischia of the third and fourth pereopods are decidedly variable, and in one of the first form males the distal extremity of the hooks is concave, suggesting

the clearly bituberculate condition of the hooks on *P. (L.) acherontis*. The sternum immediately anterior to the annulus ventralis in all of the females is tuberculate, and there are always projections extending posteriorly from the margin, a large pair flanking the median cleft and occasionally smaller ones that, like the large ones, may be spiniform or rounded.

Relationships.—As stated in the introductory remarks, *Procambarus (Lonnbergius) morrissi* has its closest affinities with *P. (L.) acherontis*. Disregarding the secondary sexual features, with the exception of the narrower areola of *morrissi*, one would have difficulty in recognizing this crayfish as different from Lönnerberg's species. Similarities are also readily evident in the structure of the first pleopod of the male, especially that of first form individuals: the long, only slightly reflexed shaft, the comparatively short mesial lamella, the arrangement of the caudal process and caudal knob, and the distally directed central projection. Pertinent also is their unique sharing of the entocytherid symbiont cited under "Associates."

Several features in addition to the short areola (less than 11 times as broad as long) serve to distinguish *morrissi* from *acherontis*: the hooks on ischiopodites of the third and fourth pereopods are not bituberculate; the cephalic process of the first pleopod is well developed; the mesial process is lacking; and no cephalolateral tubercles are present on the annulus which bears a circuitous sinus.

We call attention to the fact that in the Cambaridae only in *Faxonella clypeata* (Hay, 1899) is the mesial process of the first pleopod of the male greatly reduced and even sometimes absent (see Hobbs 1981: fig. 104b, c). Astounding to us was the observation that also a nearly identical sinus pattern occurs in the annulus ventralis of the two species (see Hobbs 1981: fig. 104d). Is it possible that these secondary sexual features have been developed independent-

ly in what we and others have considered to be such disparate species groups?

Associates.—This crayfish is infested with peritrichs and two species of entocytherid ostracods: *Uncinocythere ambophora* (Hobbs & Walton, 1959) and an unidentified member of the genus *Entocythere*. Whereas three copulating pairs of the former were found, only a single female of the latter was retrieved from the sediment in the container in which the crayfish were preserved. The only host that has been reported previously for *U. ambophora* is *P. (L.) acherontis*.

Etymology.—This crayfish is named in honor of Tom Morris, biologist and cave diver, who collected the type series and provided detailed information on Devil's Sink. Mr. Morris has been working closely with the authors in their survey of the troglobites of Florida and has provided valuable specimens from many otherwise inaccessible (to us) cave sites in the northern part of the state.

Acknowledgments

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- (HHH) Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560; (RF) Florida Museum of Natural History, University of Florida, Gainesville, Florida 32611.